

# Energy Storage Grand Challenge - RFI response

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# Idaho National Laboratory Energy Storage Grand Challenge

Request for Information response –  
Response due 2020 August 31



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Idaho National Laboratory (INL) is operated by Battelle Energy Alliance LLC for the U.S. Department of Energy (DOE). INL conducts research in energy storage (ES) and ancillary fields for several DOE offices including, EERE, NE, FE, and OE. In addition, INL conducts related research for DOD, DHS, state agencies, utilities, and technology developers. INL has developed significant expertise in ES. In July 2020, DOE released the Energy Storage Grand Challenge (ESGC) Roadmap and in conjunction, a Request for Information (RFI) regarding the content of the roadmap. INL is qualified to provide a response to the RFI.

## Roadmap tracks:

1. Technology Development Track — Eric Hsieh, OE
2. Manufacturing and Supply Chain Track — Valri Lightner, EERE
3. Technology Transition Track — Marcos Gonzales Harsha, OTT
4. Policy and Valuation Track — Alejandro Moreno, EERE (WPTO)
5. Workforce Development Track — Linda Horton, Office of Science (SC)

## INL Staff Contributors

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## Track 1: Technology Development

### 1. Use Cases – Facility Flexibility

With the exception of use case 6(b) that points to industry process applications as a component of facility flexibility, efficiency and value enhancement, the cases focus on electrical applications. Use case (2) could be more valuable if it were expanded to non-electrical energy needs of remote

communities. This case seems to ignore other potential energy needs that might exist in such a community that could benefit from a microgrid based energy park – use of heat for district heating, desalination, etc. Thermal or chemical energy storage could be key enabling technologies to support these applications in remote regions by establishing “isolation” between subsystems. By only pointing to this type of application in (6) opportunities are missed. Similar considerations could be made for case (5). Figure 2 in the roadmap illustrates an electricity-centric view. Even 6(b) only shows electrical linkage to the broader system. We really need to shift thinking to an *energy* perspective versus an *electricity* perspective. A majority of our energy generation technologies produce heat as their primary product, not electrons.

In Figure 3 of the roadmap use cases are linked to energy storage technologies. In this case, electrical and mechanical technologies are shown as “bidirectional,” which have the ability to absorb excess electricity or deliver electricity. Chemical technologies (reversible H<sub>2</sub> fuel cells) and thermal technologies could also be considered “bidirectional.” Although mentioned in the text, it is not highlighted in the figure.

## **2. Use Cases – Department of Defense**

Use cases from the Department of Defense (DOD) should be included. As the world’s largest user of energy, the DOD offers a unique testing ground for DOE ESGC technology development efforts. To the extent commercial and industrial use cases can be designed to align with DOD-specific use cases (e.g. island and remote energy storage use cases match military forward operating locations, electrified transportation match military non-tactical vehicle use), there are two significant benefits:

1. DOD can serve as a testing, deployment, and transition partner; and
2. DOD may be a secondary source of cost share to help mature technology development.

Newly announced partnerships between the Advanced Research Projects Agency- Energy (ARPA-E) and the DOD Environmental Security Technology Certification Program (ESTCP) ([Link](#)) demonstrate an ideal mechanism to make this happen. Moreover, integration with other existing cross-agency Memorandum of Understanding (MOUs), such as the Pathfinder Initiative to Project US Energy Infrastructure ([Link](#)) provide added mechanisms to align use cases and scale adoption.

## **3. Use Cases – Transformative approaches**

DOE ESGC should consider more game changing use case applications for energy storage, principally space-based energy storage for transport and stationary applications (e.g. nuclear batteries) and electrified aviation storage. These more nascent and niche applications allow the research community to advance the fundamental science and development around these applications and push the boundaries of science that would benefit more traditional energy storage use cases.

## **4. Are energy storage systems relevant for improving industrial facility operations?**

Yes, storage technologies can decouple generation (e.g., nuclear generation) from the load (e.g., industrial facility) effectively eliminating the potential contamination of the end product under a failure scenario (e.g., breach of a steam generator tube). Separation of these systems via storage

open significant new opportunities to use non-emitting nuclear generation or renewable sources to support large-scale industrial thermal energy demands.

**5. Could the storage of energy or materials contribute to increased flexibility, and in what way?**

Yes, a thermal generator can operate at nominal capacity to support both electrical demand (e.g., grid) and a thermal demand (e.g. industry). If there is a storage component between the generator

**6. Energy storage testing and validation**

Successful energy storage systems such as batteries must last thousands of cycles for both charge and discharge over a wide range of environmental conditions. Full testing and validation requires robust facilities with broad capabilities to test materials from the coin cell scale through full cell packs. DOE ESGC should ensure public access to established testing facilities

**7. Accelerating energy storage testing and validation**

Understanding degradation pathways and lifetime performance of batteries requires years of testing and validation. DOE ESGC should support development of uniform data sets for battery testing that include materials, devices, and performance. The ESGC should also support development of machine learning (ML) tools that leverage the datasets. The ML tools could be used to develop models for degradation and lifetime performance based on short time frame performance testing.

**Track 2: Domestic Manufacturing**

**1. Critical Materials Institute**

The DOE ESGC should coordinate activities with the DOE-AMO Critical Materials Institute (CMI) Innovation Hub. CMI is developing and testing new specialized materials for manufacturing, as well as the research and application testing of intelligent and resilient systems to produce new, more effective approaches to manufacturing. CMI supports early-stage research to advance innovation in U.S. manufacturing. CMI seeks ways to eliminate and reduce reliance on rare-earth metals and other materials critical to the success of clean energy technologies. The CMI has four major focus areas that closely align to the Domestic Manufacturing track:

1. The CMI focus area of Diversifying Supply researches how to expand sources of rare earth elements and critical materials, develop transformative processes and find new uses for co-products.
2. The CMI focus area of Developing Substitutes researches magnets with reduced rare earth content.
3. The CMI focus area of Reuse & Recycling researches energy storage systems, ways to enable and optimize co-production and electric machines.
4. The CMI focus area of Crosscutting Research creates new ways to enable science, sustain the environment and analyze the supply chain and economics of rare earth elements and critical materials.

**2. End of life battery triage**

When batteries are removed from a vehicle there are several potential pathways. If the battery is not aged (e.g. after an accident in which the battery was not involved), there is a potential for reuse.

That reuse could be back into a vehicle after some restoration. If the performance is below standard for a vehicle, the battery could also be deployed for stationary storage. If the performance is significantly degraded, it would be sent for materials recovery at a recycling facility. DOE ESGC should develop battery triage metrics and support capabilities for rapid triage. The triage system could be designed from the ML system that has analyzed the battery performance datasets.

### **3. The Cybersecurity Manufacturing Innovation Institute (CyManII)**

DOE-AMO recently funded CyManII, an Institute focused on cybersecurity impacts on manufacturing. DOE ESGC should coordinate activities with CyManII.

### **4. Resilience Optimization**

INL is leading research efforts and technology bridging partnerships through the INL Resilience Optimization Center (INL ROC), a national center for systems resilience and risk management, which was established in June 2019 as a virtual center bringing together the resilience related capabilities of the lab spanning modeling and simulation to virtualization to small scale test beds, to full scale testbeds to provide support sponsors in preparing for and managing resilience impacts on various critical infrastructure sectors, to include the power sector. Specific relevant expertise includes supply chain modeling for rare earth elements (REEs).

## **Track 3: Technology Transitions**

**1. DOD Technology Demonstrations** - The DOE ESGC should strongly consider strengthening existing partnerships with DOD pursuant to those areas described in Track 1 to expand DOD focused technology demonstrations in macrogrid, microgrid, advanced transportation, and deployable (device level, human level, system level) energy storage applications. Given the urgent need for innovative energy storage technologies in DOD facilities and operational energy environments, DOD provides a large and tangible application space with the added benefit of speed and efficiency of demonstrations and cost share with a Federal partner.

**2. Tools for technology transition at the National Laboratories** - DOE has several tools developed for technology transitions from the National Laboratories and University that ESGC could advance and benefit from.

### **3. National Laboratory researchers**

National Laboratory researchers have developed technologies that directly impact the ESGC.

- ESGC could guide researchers by supporting the researcher's participation in Energy i-Corps to develop entrepreneurial skills. ESGC could also support enabling researcher to take an entrepreneurial leave to advance technologies where they contributed to the intellectual property. ESGC should support the researcher should be able to negotiate a license option prior to taking a leave.
- Program such as the Technology Commercialization Fund (TCF) should be fostered by ESGC. ESGC should support seed TCF grants prior to the researcher finding a potential commercialization partner.
- ESGC should support enhancement of the entrepreneur-in-residence (EIR) program. ESGC could support EIRs that cover a portfolio of related technologies across multiple national laboratories.

- The National Laboratories have unique facilities that could accelerate commercial deployment of energy storage. ESGC should expand the access to critical facilities such as INL's Battery Test Center (BTC) by supporting the Voucher Program. Vouchers provide companies with access to facilities that could take years off the commercialization process. With National Laboratory validation, could provide support for investment in nascent technologies.

#### **Track 4: Policy and Valuation**

Adequately addressed in the National Laboratory workshop in August 2020.

#### **Track 5: Workforce Development**

##### **1. Career Mapping**

A holistic study of skills mapping for the energy storage workforce of the future is an obvious need. With information on what this looks like 5 years, 10 years, etc, into the future, this information can be fed into curriculum and pipeline development from k12-to-job. An example is the Energy Pipeline for Idaho Partnership in Education (E-PIPE), a CAES initiative-in-development that aims to streamline a robust, integrated network of energy education opportunities, pathways, and programs from k12-to-job, as formal courses of study, with multiple onboard and offboard options (k12, 2-year, 4-year, graduate). An added benefit is the assembly of a broad ecosystem of energy educators, supporters, and stakeholders across the state. The initiative also provides some focus on diversity of the pipeline. Linking energy industry needs with the higher education system enable the energy workforce development. An example is the developed pathway for College of Eastern Idaho students to easily transfer to Idaho State University's Energy Systems Technology Education Center program, and upon completion, be hired at INL.

Providing a career map of resources for the workforce is another tool that would benefit the energy storage workforce pipeline. Illustrating the paths from K12 to technical and community college programs, to bachelor's degrees, and then advanced degree options in energy storage is helpful for students, military personnel, and for use in planning the retraining of current employees. Industry benefits by influencing the skills needed at each level of the process. As an example of a piece of this, the State of Idaho's Leadership in Nuclear Energy (LINE) Commission created a tool for students to understand what local degrees would help them access jobs in nuclear energy in the state.

##### **2. Faculty-Lab Partnerships**

It's critical to build 1-on-1 research partnerships between national laboratory researchers and faculty. In addition to the normal benefit of collaborations to accelerating research outcomes, these long-term relationships between faculty and lab researchers lead to funding for students attached to collaborative projects with products aligned with DOE aims, mentorship from world-class researchers, and an opportunity to learn more about pathway to national laboratory employment.

As an example, the CAES Summer Visiting Faculty Program pairs and provides summer funding for selected faculty members to work jointly with an Idaho National Laboratory researcher on a

joint proposal for external funding. Faculty members are exposed to the inner workings of a national laboratory, learn about national laboratory capabilities and expertise, and build lasting networks while laboratory researchers build new academic connections, are exposed to diversified funding opportunities, and have the potential to work with and connect with students supporting the faculty member. To date, CAES has matched over 75 individuals.

To challenge faculty from various STEM fields to apply their knowledge to energy storage, this type of program could be adjusted to increase investment in energy storage workforce development by designating research areas as energy storage.

### **3. Experiential Learning**

Hands-on learning opportunities allow students to see how what they are learning can be applied to real problems that have national and global significance. This can be accomplished through internships, fellowships, and mentoring related to national laboratories. Depending on the student's needs, coops may be the practical solution for their hands-on experience. Positive student experiences via these hands-on experiences and good mentoring can ignite their interest in specializing in energy and/or joining the energy storage workforce.

INL and the CAES facility offer a mix of internally and externally-funded options for hands-on student learning. Access to world class laboratories and facilities motivate students to continue solving problems as they transition to professional careers. For example, the Microscopy and Characterization Suite (MaCS) is a state-of-the-art materials characterization laboratory that provides broad material-analysis capabilities at CAES. MaCS was established at CAES to attract more students into science and engineering careers, to improve science and engineering education at the undergraduate and graduate levels, and to foster leading research and interaction with local industry. MaCS staff – a mix of university faculty and INL researchers - provide one-on-one mentorship and training on specialized equipment that can be helpful in developing skills that individuals, whether students or other researchers, can draw on in future roles.

An example of engaging students in solving industry problems is the CAES Technical Assistance Program (CTAP) which engages the expertise of faculty and students to solve technical challenges facing industry. If a company has a challenge, it can reach out to CTAP, which pairs the company with expertise and capabilities—faculty and students associated with a university lab—to resolve the issue. By employing students wherever possible, CTAP allows young professionals to gain relevant work experience and industry connections that ready them for the workforce after graduation. In some cases, a student's experience serves as a springboard to positions in industry. In addition, participation in CTAP projects helps university faculty understand the needs and processes of Idaho industry.

The Industrial Assessment Center (IAC) is part of the CAES Energy Efficiency Research Institute (CEERI) based at Boise State University and supported by the Department of Energy. The IAC brings together BSU and University of Idaho to train engineering students with the hands-on experience in assessing the energy usage at small-to-medium-sized regional industrial facilities. Over the period of operation, 100+ engineering students have participated.

### **4. Joint Educational Offerings**



A framework for joint energy storage certificate offerings is another possible avenue for workforce development in a specialty area such as energy storage. When multiple universities are able to combine resources to provide a unique, world class curriculum, everyone wins. University enrollment and funding increase, students expand their knowledge in specific areas that can lead to better employment, and industry benefits by being able to steer unique curriculum needs to create a robust pipeline in critical areas such as energy storage.

An example is a CAES initiative to create the first joint certificate between the CAES universities to fill a workforce need at Idaho National Laboratory and across the nation in nuclear cybersecurity and nonproliferation. The Nuclear Safeguards and Security joint-certificate program is designed to share resources of our five member organizations. This joint effort allows a student to take a series of four 4-credit courses, each taught by a different CAES member university and thus lowering the resource/expertise burden on any one institution. Following completion of the online course work, students will participate in a world-class hand-on module at Idaho National Laboratory which will attract enrollment from around the world and provide a first-touch with the national laboratory system. The student gains valuable education and practical experience in a specialized field of study not commonly taught at U.S. universities but which will satisfy future workforce needs. The 3-year development of the Nuclear pilot, focusing on streamlining administrative barriers between universities, will lay the framework for rapid joint certificates in any area, including the potential for a future energy storage certificate.

## **5. Curriculum Exposure**

Energy storage – and even more broadly, energy at large – is not typically found in traditional undergraduate curriculum. Exposure to the potential for applying physics, engineering, and other degrees to the energy industry needs to be happening early and often to build interest in completing cross-disciplinary curriculum and training pathways to energy industry. Creating and maintaining connections between university curriculum and scientific trends is a valuable way to ensure the energy storage workforce pipeline provides the required workforce talent. These connections can also inspire innovation in problem solving.

The CAES entities have a mechanism available to design these collaborations in the form of a joint appointment. A joint appointment is an arrangement in which a researcher has formal ties to both a university and INL. These partnerships enhance collaboration, as joint appointees may conduct research and development at both home and host institutions, mentor and serve and thesis advisors for students, teach courses and seminars, and provide information about the DOE system. A joint appointment agreement can also allow for the development of a joint world-class research program (see Experiential Learning).

## **6. Capstone Courses**

There's an opportunity to influence undergraduate and graduate students by exposing them to capstone courses related to real-world energy storage challenges. Applying the theoretical knowledge gained in the classroom to solving problems allows students another opportunity for hands-on, engaging experience in an applied field that could influence their future training, specialization, curriculum decisions, and job applications.

By aligning national lab mentors and their project needs in energy storage, students gain valuable experience and excitement for their future work. CAES is working to streamline lab-university pairing for capstone course projects in energy.

## **7. Reskilling/Upskilling**

Reskilling and upskilling of the current workforce can be another way to create and maintain a robust energy storage workforce, with a focus on the critical energy storage areas mapped in #1. Close connections between employers and colleges/universities allows employers to take advantage of the education mission already in existence, while allowing for specialized needs to be met. For instance, CAES recently sponsored two specialized bootcamps, one on data analytics and one on cybersecurity, that leveraged the regional faculty, national lab expertise, and pool of regional students. One allowed for participants to earn university credits. Full degrees can also be highlighted to employees, if a special connection with a university is created. For instance, Idaho National Laboratory has special contracts with three of the CAES universities such that employees can earn certain degrees free of charge to the individual. These long-term contracts have also enabled creation of specialized degrees addressing INL needs. Finally, long-term contracts between the lab and these universities have led to creation of a lab-adjacent university campus which attracts faculty and students to the area which benefits the collaborative CAES (INL-university) research portfolio.